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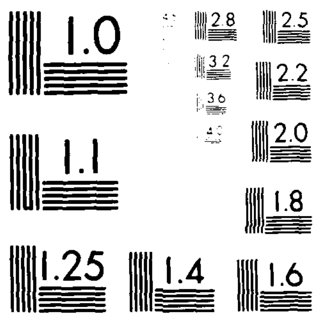

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STRATOSPHERIC RESIDENCE TIMES FROM BALLOON MEASUREMENTS OF WIND SHEARS

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Final Report
1 July 1979 - 31 December 1980

31 January 1981

AIR FORCE GEOPHYSICS LABORATORY
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Corona Anemometer

20. Abstract

The analysis of winds measured by a corona anemometer during a 10-hour balloon flight in the stratosphere between altitudes of 17 km and 25 km has been completed. Calibration of the anemometer was accomplished by cross-correlation with a wind velocity measured from radar track of the balloon. Instrumental noise in the corona anemometer has been estimated, and its effect on calculation of wind shears is discussed. Stratospheric turbulence has been calculated from local wind shears and local temperature profiles.

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STRATOSHERIC RESIDENCE TIMES FROM BALLOON MEASUREMENTS OF WIND SHEARS

NORMAN ROSENBERG, PRINCIPAL INVESTIGATOR

FINAL REPORT 31 JANUARY 1981
EUROPEAN OFFICE OF AEROSPACE RESEARCH GRANT F49620-79-C-0180

ABSTRACT

THE ANALYSIS OF WINDS MEASURED BY A CORONA ANEMOMETER DURING A 10-HOUR BALLOON FLIGHT IN THE STRATOSPHERE BETWEEN ALTITUDES OF 1[illegible] KM AND 25 KM HAS BEEN COMPLETED. CALIBRATION OF THE ANEMOMETER WAS ACCOMPLISHED BY CROSS-CORRELATION WITH A WIND VELOCITY MEASURED FROM RADAR TRACK OF THE BALLOON. INSTRUMENTAL NOISE IN THE CORONA ANEMOMETER HAS BEEN ESTIMATED, AND ITS EFFECT ON CALCULATION OF WIND SHEARS IS DISCUSSED. STRATOSPHERIC TURBULENCE HAS BEEN CALCULATED FROM LOCAL WIND SHEARS AND LOCAL TEMPERATURE PROFILES.

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STRATOSPHERIC RESIDENCE TIMES FROM BALLOON MEASUREMENTS OF WINDS

NORMAN ROSENBERG

OBJECTIVE

THE PURPOSE OF THIS PROJECT IS THE MEASUREMENT OF STRATOSPHERIC TURBULENCE USING A NEW WIND SENSOR WITH HIGH FREQUENCY RESPONSE. THE STATISTICS OF OCCURENCE OF STRATOSPHERIC TURBULENCE IS A DESIRED INPUT FOR MODELS OF STRATOSPHERIC RESIDENCE TIMES FOR CONTAMINANTS AND AS AN INPUT FOR MODELS OF OPTICAL AND RADAR SCATTERING WITHIN THE REGION.

BACKGROUND

PREVIOUS STUDIES OF STRATOSPHERIC WINDS AND TURBULENCE HAVE USED RADAR-TRACKED BALLOONS AND CHAFF, AND MEASUREMENT OF SMOKE TRAIL DISTORTION AND SPREADING. CALCULATION OF VELOCITY AND SHEAR FROM THESE TYPES OF MEASUREMENTS REQUIRES SUCCESSIVE DIFFERENCING OF THE RAW DATA WHICH LEADS TO INCREASING INACCURACY WITH EACH DIFFERENCING. FURTHERMORE THEIR SPATIAL RESOLUTION IS POOR AND DOES NOT PERMIT ASSIGNMENT OF SHEARS OVER SMALL HEIGHT DIFFERENCES.

THE DEVELOPMENT OF THE CORONA ANEMOMETER (CORONAM) WHICH DIRECTLY MEASURES A LOCAL WIND WITH SUBSTANTIALLY NO INERTIA REDUCES THE CALCULATION OF SHEAR TO A SINGLE DIFFERENCING. THIS INSTRUMENT HAS BEEN CARRIED ON A NUMBER OF BALLOON FLIGHTS OF SOME HOURS TO STUDY SHEAR STRUCTURE OVER EXTENDED PERIODS DURING BALLOON ASCENTS AND DESCENTS THROUGH A GIVEN ALTITUDE REGION.

A 10-HOUR FLIGHT MADE IN APRIL 1977 FROM HOLLOMAN AFB WAS SELECTED FOR FIRST ANALYSIS. THE PAYLOAD INCLUDED TWO CORONAMS WHICH HAD BEEN CALIBRATED IN WIND-TUNNEL LOW-PRESSURE ENVIRONMENT. IT ALSO CARRIED PRESSURE AND TEMPERATURE SENSORS. THE BALLOON WAS RADAR-TRACKED THROUGH THE FLIGHT WHICH ESTABLISHED X,Y AND Z COORDINATES WHICH PERMIT INDEPENDENT ESTIMATES OF VELOCITY AND SHEAR (WITH LOW FREQUENCY RESPONSE.) THE RADAR DATA IS VERY IMPORTANT IMPORTANT IN INTERPRETATION OF THE CORONAM DATA.

DATA SELECTION

A DIGITAL TAPE WAS PREPARED WHICH MERGED DATA FROM THE PAYLOAD INSTRUMENTS AND FROM THE RADAR TRACK FOR 2300 TIMES BETWEEN 0500 AND 1500 LOCAL (MST) TIME. TABLE 1 SHOWS THE SPECIFIC DATA AVAILABLE FOR EACH TIME.

THE ALTITUDE DERIVED FROM THE PRESSURE SENSOR WAS FOUND TO DIFFER FROM THE RADAR-MEASURED ALTITUDE BY UP TO 1000 METERS. THE MORE DIRECT ALTITUDE MEASUREMENT FROM THE RADAR TRACK WAS USED IN THE ANALYSIS. CORONAM 2 WAS NOT FUNCTIONAL, SO ONLY CORONAM 1 WAS AVAILABLE FOR ANALYSIS.

THE INSTRUMENT PLATFORM WAS SUSPENDED ABOUT 260 METERS BELOW THE BALLOON. THE CORONAM MEASURES THE WIND IT SENSES, TO WHICH MUST BE ADDED ITS OWN VELOCITY WHICH IS THAT OF THE BALLOON TO WHICH IT IS SECURED. THIS MAKES POSSIBLE A CALIBRATION OF THE CORONAM VELOCITY WHICH MUST BE EQUAL (EXCEPT FOR HIGH-FREQUENCY CONTENT) TO THE DIFFERENCE BETWEEN RADAR MEASUREMENTS OF BALLOON VELOCITY AT THE TIME OF THE CORONAMETER MEASUREMENT AND BALLOON VELOCITY AT A TIME WHEN IT IS 260 METERS LOWER THAN ITS CURRENT ALTITUDE. THIS IMPLIES THAT CALIBRATION OF THE CORONAM CAN BE DONE DURING BALLOON ASCENTS AND DESCENTS WHEN THE REQUIRED RADAR DATA IS AVAILABLE IF WIND CHANGES AT EACH ALTITUDE ARE SMALL DURING THE INTERVAL BETWEEN THE TWO MEASUREMENTS.

THE FLIGHT INCLUDED FIVE LEGS WHERE THE BALLOON WAS DESCENDING OR ASCENDING OVER A 3000 TO 7500 METER ALTITUDE INTERVAL AND ANALYSIS WAS CARRIED OUT FOR THESE FIVE LEGS LISTED IN TABLE 2.

TABLE 1 LIST OF RAW DATA ON TAPE H7727

1. LOCAL TIME (MST) HHMMSS
2. ALTITUDE (METERS) FROM PRESSURE
3. TEMPERATURE (K)
4. PRESSURE (MBAR)
5. CORONAM 1 VELOCITY (M/S)
6. CORONAM 1 AZIMUTH (DEG)
7. CORONAM 2 VELOCITY (M/S)
8. CORONAM 2 AZIMUTH (DEG)
9. RADAR ALTITUDE (METERS)
10. RADAR NORTH (METERS)
11. RADAR EAST (METERS)

TABLE 2 LEGS SELECTED FOR ANALYSIS

LEG	TIME			ALTITUDE			VERT	RAW DATA PTS		AV SPACING	
UP/DN	START	END	SEC	LOW	HIGH	DIF	M/S	SCREEN	MONOT	SEC	ALT
1 U	05:06	05:50	2640	17500	25000	7500	2.8	216	215	12	34
2 U	07:51	09:42	6660	19500	25000	5500	0.8	475	369	18	15
3 D	11:23	11:59	2160	17500	21200	3700	-1.7	190	164	12	22
4 U	12:24	14:01	5700	18200	21500	3300	0.6	326	194	29	29
5 D	14:22	14:42	1200	17500	20500	3000	-2.5	106	102	12	29

DATA SCREENING

RAW DATA SCREENING WAS DONE BY REJECTING ALL POINTS FOR WHICH NO RADAR DATA WERE AVAILABLE. ALSO REJECTED WERE ALL POINTS WHERE THE CORONAM READINGS WERE CONSIDERED UNRELIABLE (PRIMARILY BECAUSE OF SCREENING OF THE METER FROM THE WIND BY PAYLOAD ELEMENTS.) THIS SCREENING REDUCED THE RAW DATA TO ABOUT 1300 POINTS. THEN THOSE POINTS WHICH WERE NOT MONOTONIC IN ALTITUDE WERE ALSO REJECTED. THE REMAINING 1000 POINTS SHOWED AVERAGE SPACING OF 15 TO 34 METERS, SO AN INTERPOLATION INTERVAL TO FIXED ALTITUDES AT 20 METER SPACING WAS SELECTED.

RAW RADAR POSITIONS WERE SMOOTHED BEFORE INTERPOLATION BECAUSE NO MEANINGFUL HIGH-FREQUENCY CONTENT IS AVAILABLE IN THESE DATA. AFTER INTERPOLATION, RADAR VELOCITIES WERE COMPUTED FROM POSITION DIFFERENCE/TIME DIFFERENCE BETWEEN SUCCESSIVE POINTS.

RAW CORONAM READINGS WERE CONVERTED FROM TOTAL VELOCITY AND AZIMUTH TO EAST AND NORTH COMPONENTS BEFORE INTERPOLATION. THE RAW CORONAM COMPONENT VELOCITIES WERE PROCESSED BY A SPECIAL FILTER WHICH REJECTED OUTLIER POINTS BUT RETAINED ORIGINAL RAW VALUES FOR ABOUT 90 PERCENT OF THE DATA IN ORDER NOT TO LOSE ANY HIGH-FREQUENCY CONTENT IN THE MEASUREMENTS.

PERSISTENCE OF STRATOSPHERIC WINDS

FIGURE 1 SHOWS THE GROUND TRACK OF THE BALLOON DURING THE FIVE LEGS AND THE ALTITUDE VS TIME OVER THE 10-HOUR FLIGHT PERIOD.

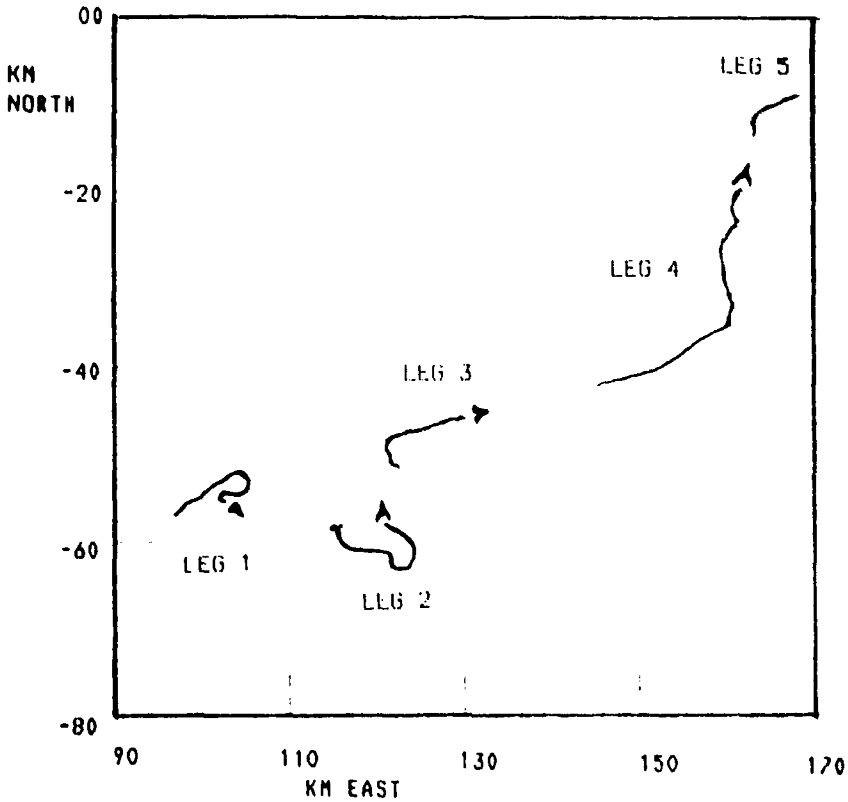
FIGURE 2 SHOWS THE RADAR-TRACK BALLOON VELOCITY COMPONENTS VS ALTITUDE FOR THE FIVE LEGS. THE VELOCITY PROFILES COVER A 10-HOUR PERIOD AND SHOW A PERSISTENT SINUSOIDAL PATTERN THROUGH THE ENTIRE PERIOD WITH A VERTICAL WAVELENGTH OF ABOUT 1000 METERS. THIS IS IN FACT A HELICAL PATTERN WHEN THE TWO COMPONENTS ARE CONSIDERED. FURTHERMORE THE SIMILARITY OF THE PROFILES SUGGEST THAT VELOCITIES WERE NOT SERIOUSLY CONTAMINATED BY VORTEX-SHEDDING AT THE BALLOON, SINCE THE FIVE LEGS VARIED IN AVERAGE VERTICAL VELOCITY FROM 2.8 M/S TO -2.8 M/S, WHICH WOULD RESULT IN SUBSTANTIAL DIFFERENCE IN VORTEX-SHEDDING CHARACTERISTICS. FIGURE 2 ALSO PRESENTS THE TEMPERATURE PROFILES FOR THE FIVE LEGS, WHICH REMAINED SUBSTANTIALLY UNCHANGED DURING THE 10-HOUR PERIOD.

CORONA ANEMOMETER CALIBRATION

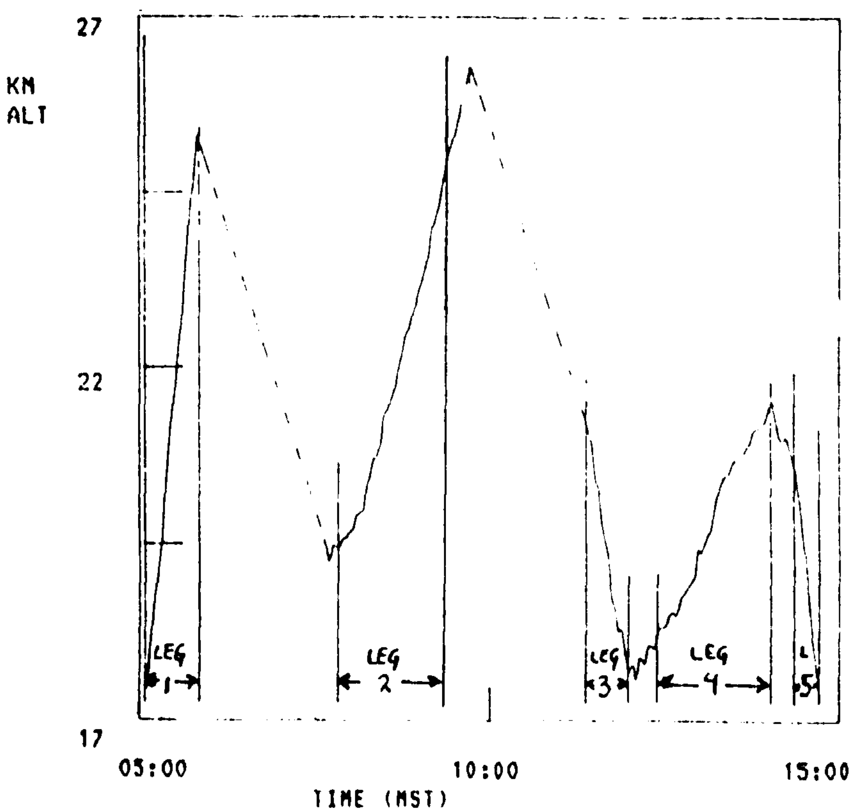
THE CORONAM VELOCITIES WILL BE CORRELATED WITH THE DIFFERENCE BETWEEN THE TOTALLY-INDEPENDENT MEASUREMENT OF RADAR (BALLOON) VELOCITIES AT THE ALTITUDE OF THE PAYLOAD AND THE ALTITUDE OF THE BALLOON. THESE BALLOON VELOCITY DIFFERENCE VALUES (VDIF) WERE CALCULATED FROM SMOOTHED RADAR DATA AND ARE PRESENTED FOR THE FIVE LEGS IN FIGURE 3. PERSISTENCE AS ORGANIZED WAVES IS EVEN MORE STRIKING IN THE DIFFERENCE PROFILES THAN IN THE ORIGINAL VELOCITY PROFILES. THE VDIF AMPLITUDE PROFILES ARE ABOUT 3 M/S WITH A DOMINANT WAVELENGTH OF ABOUT 1000 METERS.

FIGURE 1 - FLIG H7727 APRIL 1977 HOLOMAN AFB

GROUND TRACK



ALTITUDE VS TIME FOR FIVE LEGS ANALYSED



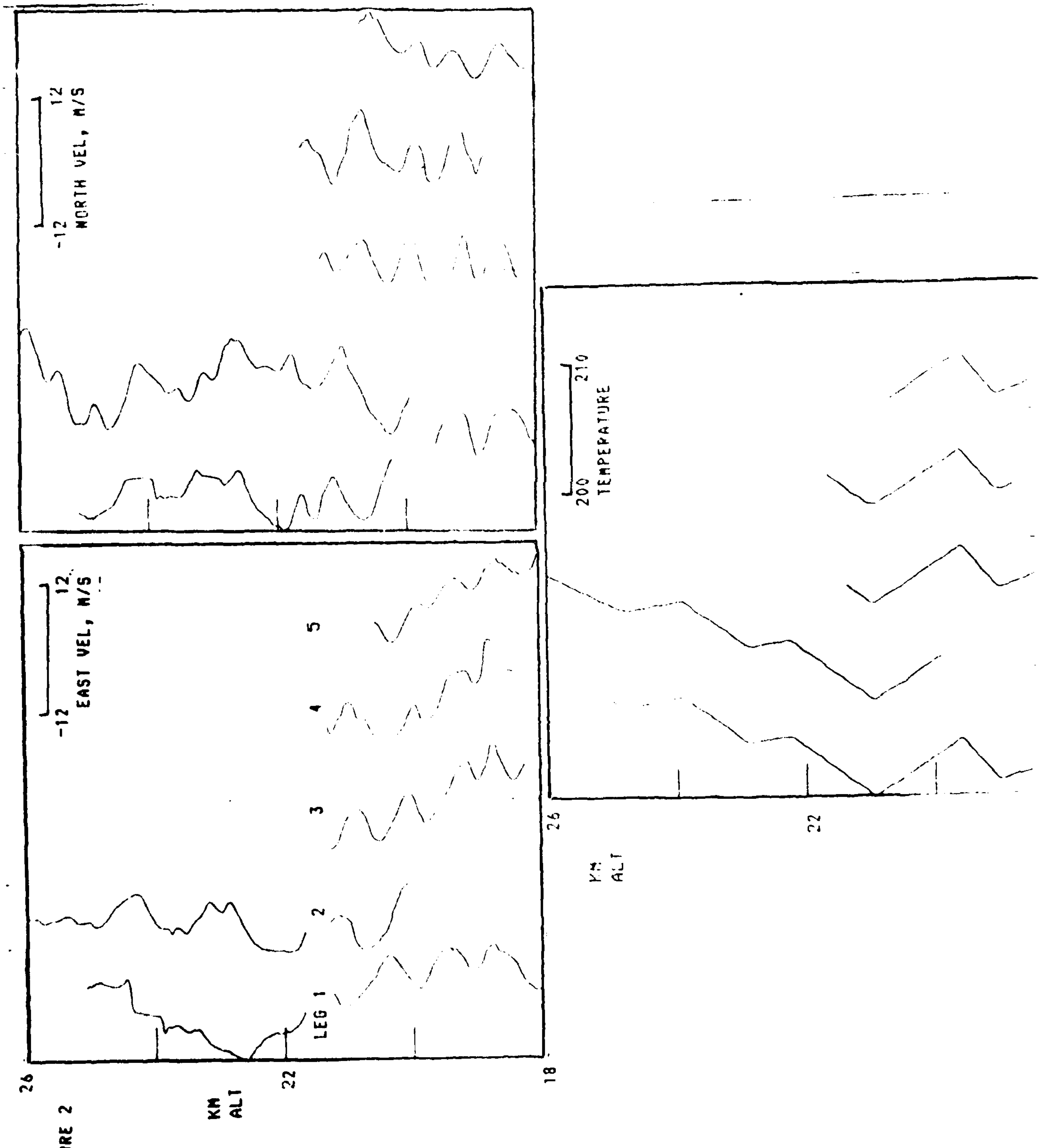
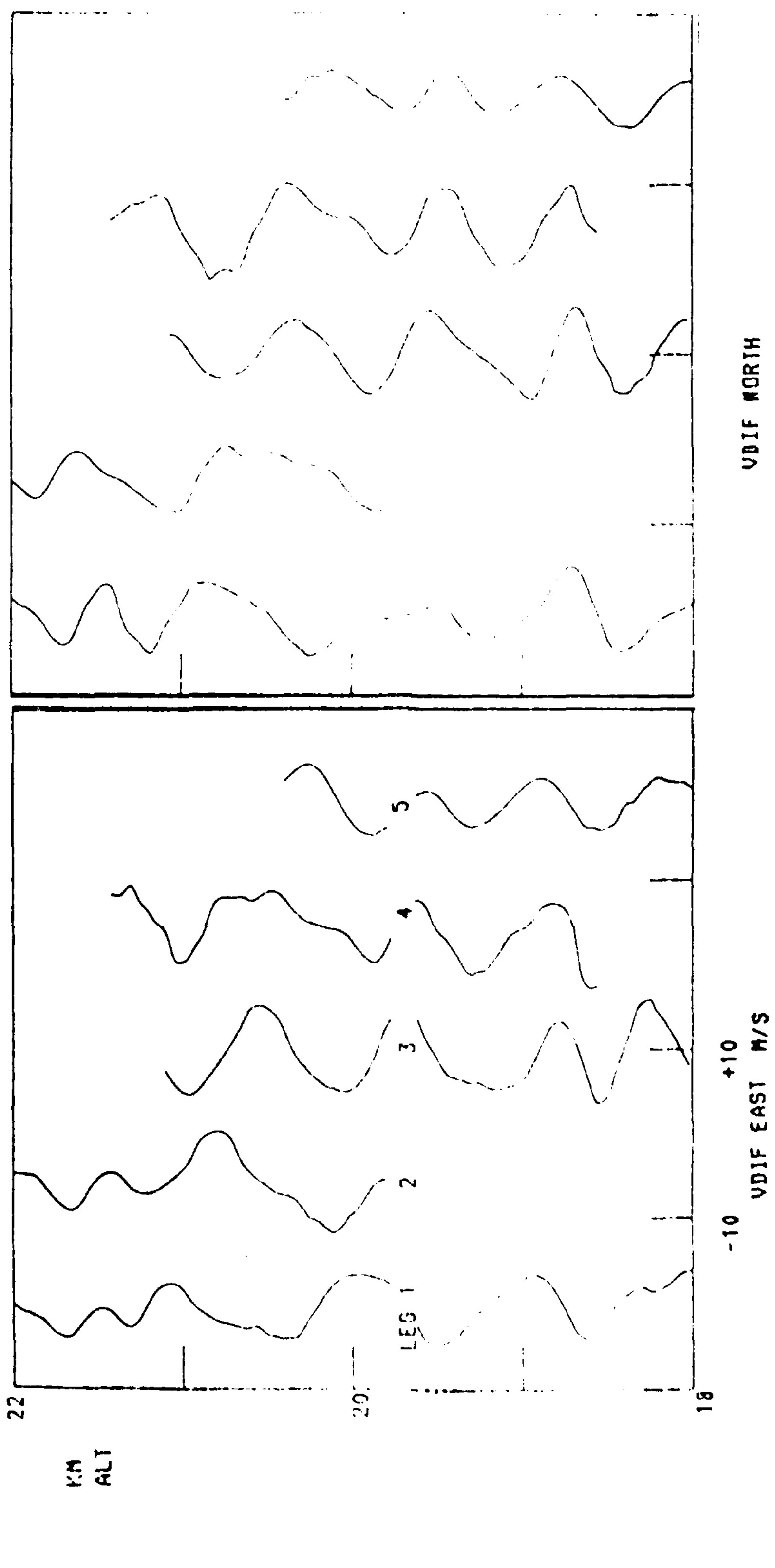

-12 NORTH VEL, M/S 12
-12 EAST VEL, M/S 12
200 TEMPERATURE 210
LEG 1
2
3
4
5
26
22
18
KM
ALT

FIGURE 2

FIGURE 3 PROFILES OF VDIF COMPONENTS FOR FIVE LEGS



THE SLOPE AND OFFSET OF THE VDIF COMPONENT PROFILE WAS FOUND BY A LINEAR FIT AND WAS ADDED TO THE CORONAM COMPONENT PROFILE BEFORE CROSS-CORRELATION. THE SLOPE-ADJUSTED CORONAM PROFILE WAS CROSS-CORRELATED WITH THE VDIF PROFILE, USING A FOURIER TRANSFORM WITH 128 POINTS (2.56 KM OR AT LEAST TWO CYCLES OF THE BASIC WAVE) IN A GIVEN CORRELATION. SEPARATE BUT OVERLAPPING CORRELATIONS WERE DONE BY MOVING THE ALTITUDE WINDOW UPWARDS BY 64 POINTS AS LONG AS DATA WAS AVAILABLE ON A GIVEN LEG. CORRELATION WAS DONE USING ONLY SPATIAL FREQUENCIES TO 1/2 NYQUIST CORRESPONDING TO 80 METERS SINCE NO SIGNIFICANT HIGHER FREQUENCY CONTENT WAS EXPECTED IN THE RADAR VELOCITY PROFILES.

THE RESULTS ARE SUMMARIZED IN TABLE 3 WHICH SHOW CORRELATIONS OF 80-95 PERCENT DEPENDING ON LEG,COMPONENT AND ALTITUDE BLOCK. TABLE 3 IS ORDERED IN BLOCKS WITH DATA FOR EACH LEG,FOR EACH COMPONENT AND FOR EACH OVERLAPPING ALTITUDE RANGE.

THE CROSS-CORRELATION ALGORITHM GIVES NOT ONLY CORRELATION BUT ALSO GIVES THE AMPLITUDE OF EACH OF THE TWO PROFILES BEING CORRELATED, AND THE LAG OR DISPLACEMENT WHERE BEST CORRELATION IS FOUND. THE LAG WAS MOST FREQUENTLY ZERO WHICH IMPLIES THAT THE TWO PROFILES ARE BEST-ALIGNED AS TESTED. LAG VALUES RANGE FROM +1 TO -3 BUT INSPECTION SHOWED THAT ZERO-LAG CORRELATIONS WRE ALMOST AS HIGH, I.E.,LAG ESTIMATES ARE NOT SENSITITIVE NEAR THE CORRELATION MAXIMUM.

THE NEXT COLUMN IN TABLE 3 PRESENTS THE AUTOCORRELATION ZERO OF THE VDIF PROFILES WHICH SHOW TYPICAL VALUES OF 13 POINTS EQUIVALENT TO 260 METERS. (IT IS A COINCIDENCE THAT THIS VALUE IS EUAL TO THE BALLOON-PAYLOAD SPACING.)

IT MAY BE NOTED THAT THE SAME CORRELATION TESTS WERE PERFORMED FOR SPACINGS OF 240,260 AND 280 METERS, AND THAT THE BEST CORRELATIONS WERE FOUND FOR THE 260 METER SPACING.

TABLE 3 CORRELATION AND CALIBRATION OF CORONAM

JLO	LOWEST POINT USED	LAG	SHIFT FOR HIGHEST CORRELATION
AUTZER	AUTOCORREL ZERO CROSSING	CORLN	CORRELATION
RADAMP	AMPLITUDE (M/S) VDIF	CORAMP	AMPLITUDE (M/S) CORONAM
AMPRAT	RATIO OF AMPLITUDES		

	JLO	LAG	AUTZER	CORLN	RADAMP	CORAMP	AMPRAT	LOOP 2 AFTER CORRECTION LAG	AUTZER	CORLN	CORAMP	AMPRAT
LEG,ALO,AHI= 1 17480. 25000.												
EAST	1	0	14	.91	2.85	2.24	1.27	0	14	.92	2.93	.97
	65	1	14	.95	2.56	2.12	1.21	1	14	.95	2.75	.93
	129	0	11	.92	1.70	1.80	.94	0	11	.92	2.30	.74
	193	0	36	.90	1.79	1.80	.99	0	36	.89	2.27	.79
	257	1	13	.84	1.69	1.30	1.30	1	13	.85	1.60	1.06
NORTH	1	0	11	.90	2.73	1.88	1.45	0	11	.90	2.47	1.10
	65	0	12	.92	2.50	1.69	1.48	0	12	.92	2.18	1.15
	129	0	12	.92	2.61	1.82	1.43	0	12	.92	2.32	1.12
	193	0	13	.88	1.93	1.26	1.52	0	13	.68	1.61	1.20
	257	2	16	.81	1.40	1.02	1.37	2	16	.81	1.28	1.10
FITTED CORRECTION			ALO,AMID,AHI=		1.33	1.29	1.24		AMID,AHI=		1.00	1.01
LEG,ALO,AHI= 2 19500. 25000.												
EAST	1	-1	16	.87	2.90	.64	4.51	-1	16	.89	2.56	1.13
	65	-1	29	.96	2.38	1.13	2.10	-1	29	.96	2.54	.94
	129	-1	16	.91	2.56	1.38	1.85	0	16	.94	2.63	.97
	193	-1	18	.92	1.85	1.17	1.58	0	18	.94	1.64	1.13
NORTH	1	0	15	.92	2.45	.53	4.65	0	15	.94	2.10	1.17
	65	-1	14	.81	2.10	.80	2.62	0	14	.87	1.77	1.19
	129	-2	14	.84	2.35	1.48	1.59	1	14	.88	2.14	1.10
	193	-1	15	.90	1.89	1.43	1.32	0	15	.90	1.77	1.07
FITTED CORRECTION			ALO,AMID,AHI=		5.79	2.69	1.24		AMID,AHI=		1.09	1.06
LEG,ALO,AHI= 3 17700. 21160.												
EAST	1	-2	11	.84	3.63	1.20	3.02	-2	11	.85	3.35	1.09
	65	-3	12	.86	3.19	1.50	2.12	-2	12	.88	2.77	1.15
NORTH	1	-2	11	.93	3.32	1.06	3.13	-2	11	.94	3.06	1.09
	65	-3	12	.84	2.44	.92	2.66	-3	12	.86	2.09	1.17
FITTED CORRECTION			ALO,AMID,AHI=		3.96	2.88	2.08		AMID,AHI=		1.10	1.20
LEG,ALO,AHI= 4 18280. 21480.												
EAST	1	0	13	.85	3.16	2.84	1.11	0	13	.85	3.31	.95
	65	0	12	.98	2.47	2.70	.91	0	12	.98	2.88	.86
NORTH	1	0	12	.84	3.38	2.49	1.36	0	12	.83	2.94	1.15
	65	0	13	.96	2.69	2.11	1.28	0	13	.96	2.33	1.16
FITTED CORRECTION			ALO,AMID,AHI=		1.39	1.20	1.04		AMID,AHI=		1.04	.98
LEG,ALO,AHI= 5 17480. 20500.												
EAST	1	-2	11	.81	2.39	1.15	2.09	-2	11	.78	2.05	1.17
	65	-2	14	.95	1.97	1.13	1.74	-2	14	.94	1.72	1.14
NORTH	1	-1	12	.83	1.87	1.00	1.86	-1	12	.83	1.79	1.04
	65	-2	11	.90	1.38	.88	1.56	-1	11	.92	1.33	1.03
FITTED CORRECTION			ALO,AMID,AHI=		2.35	1.95	1.60		AMID,AHI=		1.10	1.08

THE RMS AMPLITUDES OF THE CORONAM WAS FOUND TO BE SUBSTANTIALLY LOWER THAN THAT OF THE VDIF PROFILES, AND THIS AMPLITUDE RATIO CAN BE APPLIED AS A CALIBRATION TO THE CORONAM DATA. THE AMPLITUDE RATIOS FOR THE TWO COMPONENTS OF A GIVEN LEG WERE MERGED INTO A LEAST SQUARE BEST-FIT VS ALTITUDE. THE RESULTING CORRECTION IS LISTED FOR LOW, MIDPOINT AND HIGH ALTITUDES BELOW THE LEG DATA BLOCK IN TABLE 3. HIGHEST CORRECTION FACTOR WAS IN THE LOW-ALTIDUDE REGION OF LEG 2 WHERE A AMPLITUDE RATIO OF 5.8 WAS FOUND, TAPERING TO 1.2 AT THE HIGHEST ALTITUDE OF THIS LEG. IN OTHER WORDS,THE CORONAM SHOWS AN EXCELLENT SENSE OF DIRECTION BUT ITS AMPLITUDE VARIES FROM TIME TO TIME WITHIN THE SAME LEG AND BETWEEN LEGS IN A MANNER WHICH CANNOT BE EXPLAINED AT THIS TIME.

FIGURE 4 SHOWS VERTICAL PROFILES OF ORIGINAL CORONAM,CORRECTED CORONAM,CORONAM SHEAR AND RADAR VDIF PROFILES FOR LEGS 1 AND 2. FIGURE 5 SHOWS CORRECTED CORONAM PROFILES AND THE RADAR PROFILES AT A DIFFERENT SCALE TO POINT OUT MORE CLEARLY THE HIGH CORRELATION BETWEEN THE TWO PROFILES AFTER CORRECTION.

A SECOND CORRELATION LOOP WAS TESTED USING THE CORRECTED AMPLITUDE VALUES OF THE CORONAM WITH THE VDIF VALUES FROM THE RADAR. RESULTS ARE LISTED IN THE LAST 5 COLUMNS OF TABLE 3 AND SHOW THAT AMPLITUDES WERE WITHIN 10 PERCENT OF THE RADAR VDIF AND RETAINED HIGH CORRELATION AND LOW LAG DIFFERENCES.

FIGURE 4 PROFILES OF VDIF, CORONAM CORRECTED AND ORIG, AND CORONAM SHEAR

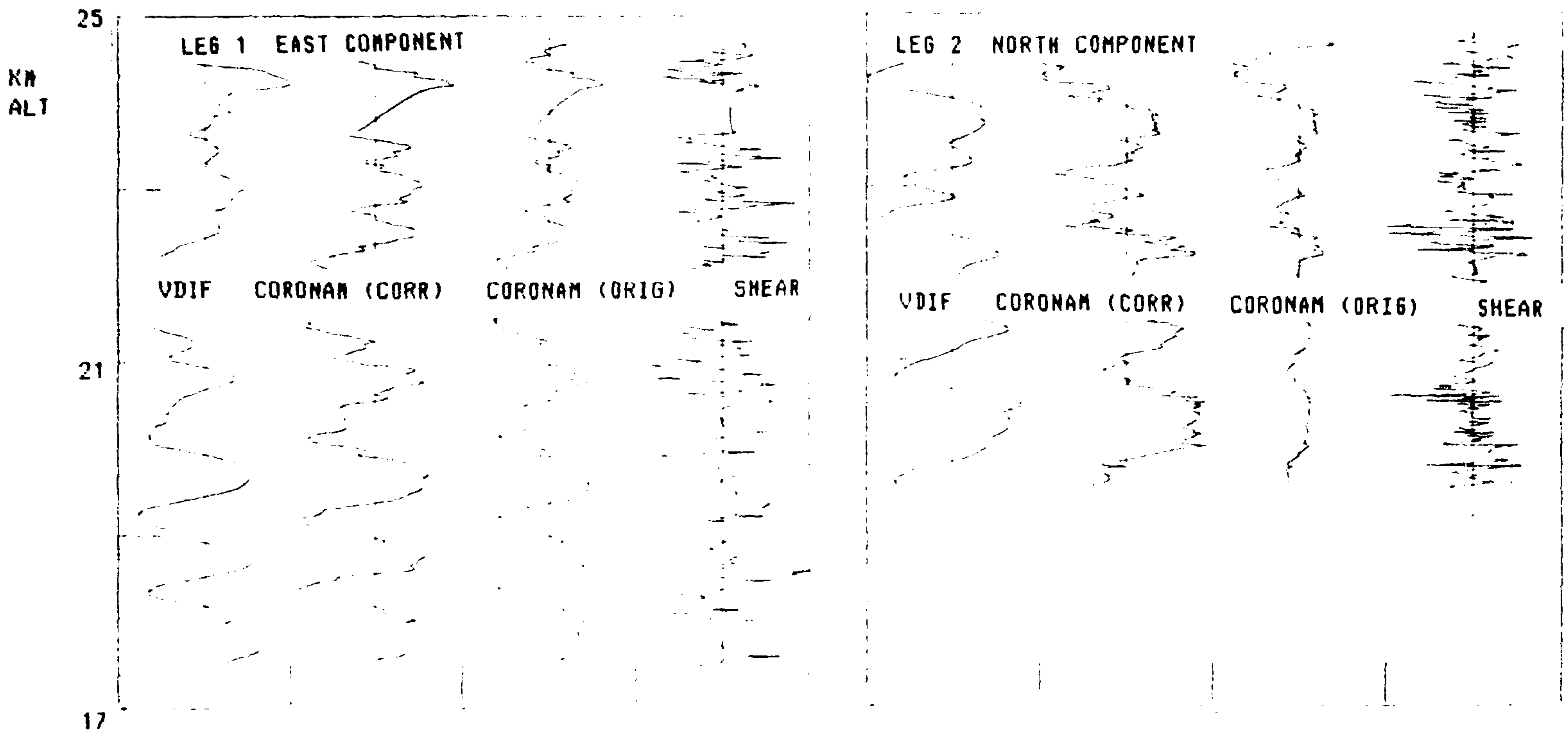
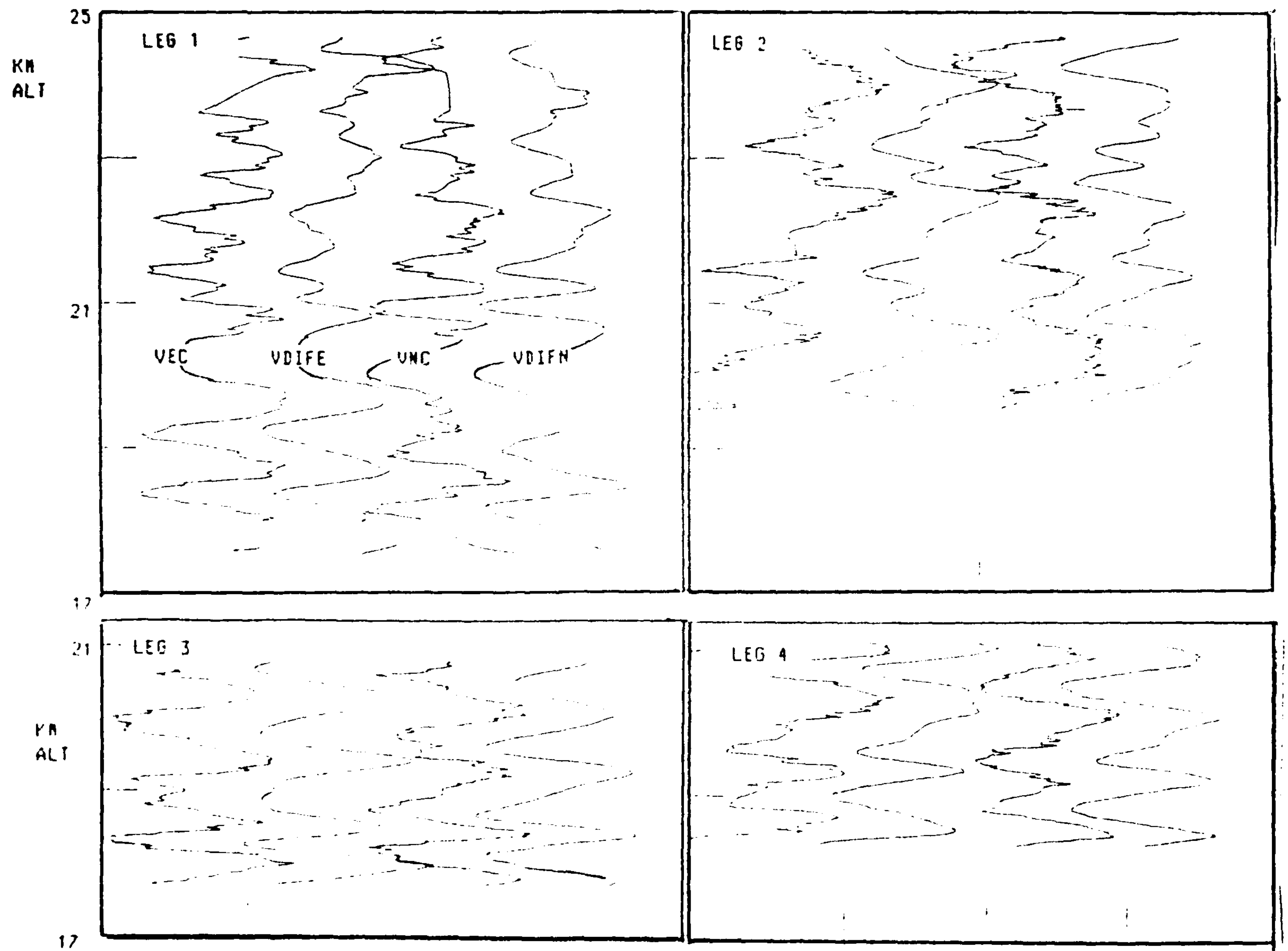


FIGURE 5 COMPARISON OF CORRECTED CORONAM PROFILES AND VDIF PROFILES



SHEAR CONTENT AND RICHA. ,ON NUMBERS

THE CALCULATION OF VERTICAL SHEAR AND RICHARDSON NUMBER REQUIRES COMPARISON WITH THE BRUNT-VAISSILI FREQUENCY AS THE BASIS FOR ESTIMATING REGIONS WITH TURBULENT CONTENT. THE BRUNT-VAISSILI FREQUENCY IS GIVEN BY:

```
 FREQ (1/SEC) = SQRT [ G/T * ( DTDZ-DTADIAB/DZ) ]
 WHERE G IS THE GRAVITATIONAL CONSTANT (9.8 MET/SEC/SEC)
       T IS THE TEMPERATURE ( DEG KELVIN)
       DTDZ IS THE LOCAL TEMPERATURE GRADIENT
       DTADIAB/DZ IS THE ADIABATIC LAPSE RATE (-.0095 DEG/MET)
```

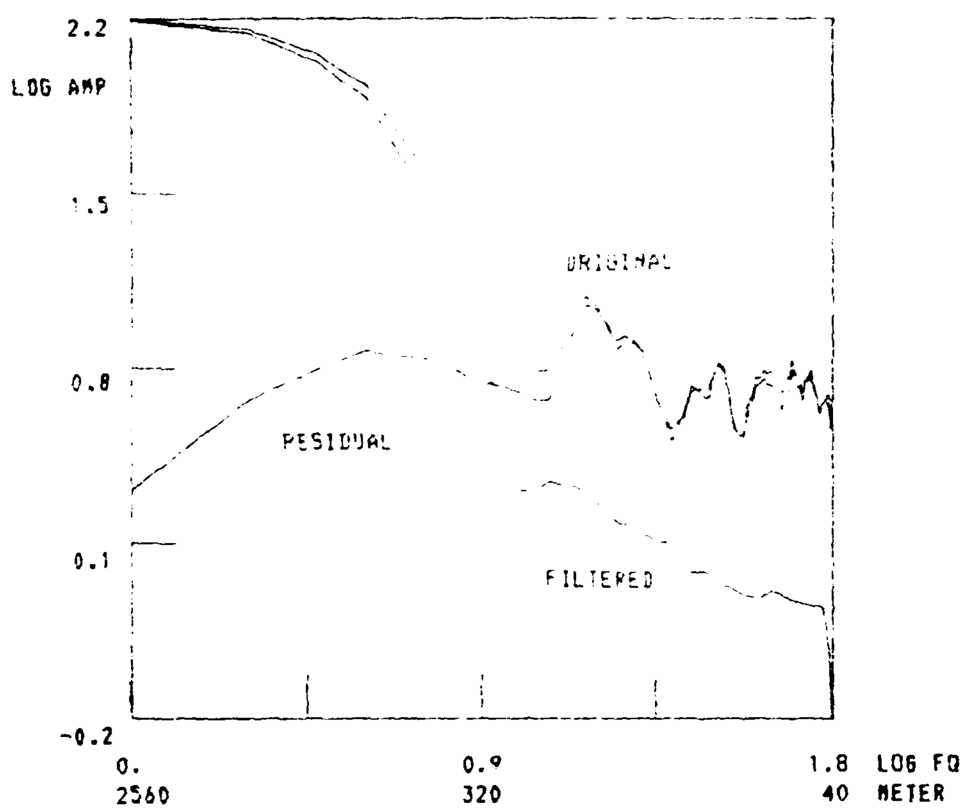
THE BRUNT PERIOD IS THE RECIPROCAL OF THE FREQUENCY AND IS A TIME CONSTANT IN SECONDS AS A RESTORING FORCE FOR ANY LOCAL PERTURBATION. THE FREQUENCY ITSELF CAN BE CONSIDERED AS A BRUNT SHEAR (MET/SEC)/MET WHICH IS RELATED TO THE RICHARDSON NUMBER=(BRUNT SHEAR/LOCAL SHEAR)**2. IT IS CONVENIENT TO EXPRESS THE SHEAR VALUES IN (MET/SEC)/KM. TABLE 4 PRESENTS THE EXPERIMENTAL OBSERVATIONS OF TEMPERATURE,DTDZ AND THE RESULTING PERIOD AND SHEAR FOR LEG 1.

TABLE 4 BRUNT PERIOD AND SHEAR VS ALTITUDE

ALT	TEMP	DTDKM	SEC	SHR M/S/KM
18000	212.79	-1.96	53.67	18.63
20000	212.73	-3.28	59.07	16.93
22000	215.23	3.20	41.59	24.05
24000	218.88	-.57	50.02	19.99

FIGURE 6 SHOWS RESULTS OF SPATIAL FREQUENCY ANALYSIS OF THE CORRECTED CORONAM COMPONENT PROFILES FOR ONE CASE. THE AMPLITUDE FALLS OFF AS EXPECTED UNTIL ABOUT 300 METER WAVELENGTH. AT SHORTER WAVELENGTHS, I.E. HIGHER FREQUENCIES, THE AMPLITUDE IS NEARLY-CONSTANT. THIS BEHAVIOUR IS A SIGN THAT THE DATA AT THESE HIGHER FREQUENCIES IS WHITE NOISE, AND MAY BE INSTRUMENTAL RATHER THAN ANY TRUE VELOCITY VALUE. FIGURE 6 ALSO SHOWS THE EFFECT OF PROCESSING THE PROFILE WITH A LOW PASS FILTER CONSISTING OF 2 PASSES WITH A 5-POINT (100 METER) RUNNING AVERAGE, AND THE AMPLITUDE OF THE RESIDUAL, I.E., THE DIFFERENCE BETWEEN ORIGINAL AND SMOOTHED PROFILES. THE AUTOCORRELATION OF THE RESIDUAL HAD ITS ZERO AT A SPACING OF 1 UNIT, ANOTHER SIGN THAT IT REPRESENTED WHITE NOISE. THE AUTOCORRELATION ZERO OF THE SMOOTHED SIGNAL REMAINED UNCHANGED FROM THAT OF THE ORIGINAL.

FIGURE 6 SPATIAL FREQUENCY ANALYSIS OF LEG2 EAST COMPONENT



BECAUSE OF THIS NOISE CONTENT, DIFFERENT SPACINGS WERE USED FOR CALCULATION OF SHEAR, BRUNT FREQUENCY AND RICHARDSON NUMBER. DATA TAKEN AT SPACING OF 1,2,4,8 AND 16 POINTS (20,40,80,160,AND 320 METERS) SHOW A DECREASING CONTENT OF HIGH SHEARS, SHOWN IN FIGURE 7 AND TABLE 5 AND 6. RICHARDSON NUMBERS OF 0.25 OCCUR AT SHEARS OF 40-50 M/S/KM DEPENDING ON TEMPERATURE GRADIENT. AS CAN BE SEEN FROM TABLE 6, ONE CAN SAY THAT 45 PCT OF THE STRATOSPHERE IS TURBULENT BY USING SHEARS AT 20 METER SPACING, OR THAT 20 PCT IS TURBULENT AT A SPACING OF 80 METERS, OR 1 PCT AT A SPACING OF 320 METERS.

WHICH SPACING SHOULD BE CONSIDERED AS REPRESENTATIVE OF THE TRUE SHEAR CONTENT OF THE ATMOSPHERE WILL DEPEND UPON A BETTER UNDERSTANDING AND CONTROL OF THE SOURCES OF THE NOISE IN THE CORONAM MEASUREMENTS.

TABLE 5 CUMULATIVE DISTRIBUTION OF SHEARS (M/S/KM) VS SPACING IN METERS

SPAC	PNTS	CUM	WITH	SHR>		20					40					60				
20	1060	1000	985	953	893	813	746	657	581	514	451	396	341	306	262	212	187	161	133	112
40	1055	1000	983	939	877	791	703	623	522	457	373	311	243	198	160	129	101	86	73	57
80	1045	1000	982	910	820	715	602	488	368	266	202	146	103	76	55	33	27	21	16	13
160	1025	1000	966	894	762	623	460	319	201	109	66	37	23	12	6	4	3	3	3	3
320	985	1000	941	811	642	430	222	75	20	6	3	3	2	2	0	0	0	0	0	0

TABLE 6 CUMULATIVE DISTRIBUTION OF SHEAR FOR RICHARDSON NUMBER=0.25

SPAC	PNTS	CUM	WITH	SHR/SHCR>.5							1.0					1.5				
20	1060	1000	982	951	882	804	718	626	547	492	447	384	325	284	240	212	183	151	131	110
40	1055	1000	979	935	862	770	680	590	515	417	355	290	237	196	154	129	105	82	66	49
80	1045	1000	977	902	796	688	580	452	358	265	194	134	95	71	52	37	29	17	12	11
160	1025	1000	963	873	739	577	440	298	200	121	74	45	21	16	11	6	3	3	3	3
320	985	1000	933	789	621	383	222	114	44	19	12	5	2	1	1	0	0	0	0	0

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